PRIMAVERA: High resolution climate processes - Impact of increase in horizontal resolution on Arctic sea ice evolution

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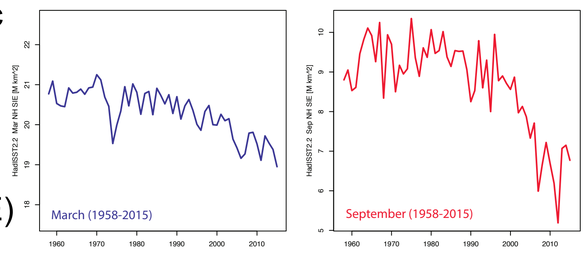
● Observed changes in the Arctic since the International Geo-physical Year 1957-58 markedly indicate that from climate per-spective we do live in interesting times: the NH sea ice extent (SIE) /cover has substantially declined



● Within the framework of PRIMAVERA project we explore the benefit of *increased horizontal resolution in ocean and sea ice* for the fidelity of historical climate variability and change on regional scales

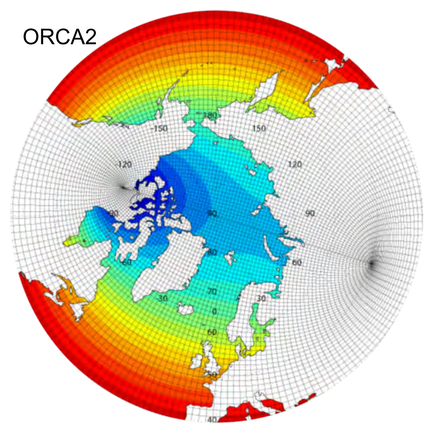
● Our methodology relies on NEMO-LIM3 ocean-sea-ice GCM for forced simulations with two different horizontal resolutions, while climate vari-ability in model's outputs is decomposed via K-means clustering analysis

● We use Nucleus for European Modelling of the Ocean model version 3.3 (NEMO3.3) with the embedded Louvain-la-Neuve sea Ice Model version 3 (LIM3) using single sea ice thickness category

● NEMO-LIM3 is forced by the DFS4.3 surface forcing fields from 1958 to 2006 following the CORE bulk formulae

● We compare results of ORCA1L46 (nominal 1° horizontal resolution) and ORCA025L75 (nominal 0.25° horizontal resolution) configurations

● NEMO-LIM3 simulations are initialized on 1 January 1958 from ensemble-mean of the ECMWF's Ocean Reanalysis System 4 (ORAS4) and the associated ensemble-mean BSC sea ice reconstruction



● Representation of internal variability modes via nonhierarchical *K*-means cluster analysis:

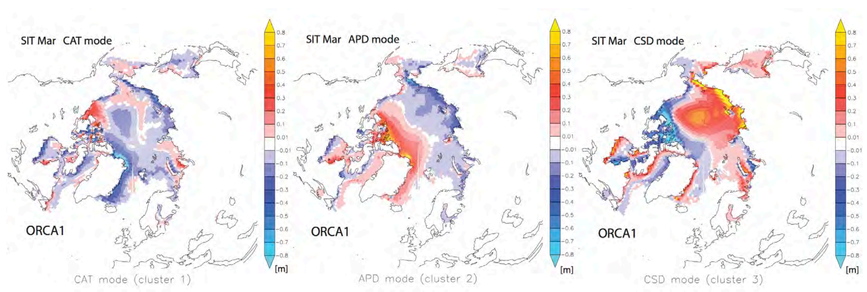
- PCA (EOF analysis) yields a low-dim. representation of data that has key variability properties, but it also has several inherent limitations: symmetry between pos. and neg. phases, suppresses nonlinearity by using a linear covariance matrix, …

- we apply K-means clustering method on the NH sea ice thickness (SIT: a key medium for sea ice memory on longer time scales) that partition SIT into modes or clusters based on their Euclidian distance to simultaneously minimize the distance between members of a given mode and maximize the distance between the centers or centroids of the clusters

- optimal number of NH SIT clusters *K*=3 has been determined in advance via hierarchical approach

Wilks D (2011) Statistical methods in the atmospheric sciences, 3rd edn. Academic Press, London, p 704

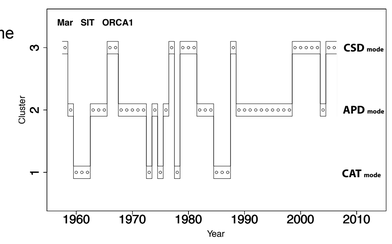
Fučkar, N.S., V. Guemas, N.C. Johnson, F. Massonnet, and F.J. Doblas-Reyes. (2015) Clusters of interannual sea ice variability in the northern hemisphere. Clim Dyn (2016) 47: 1527. doi:10.1007/s00382-015-2917-2

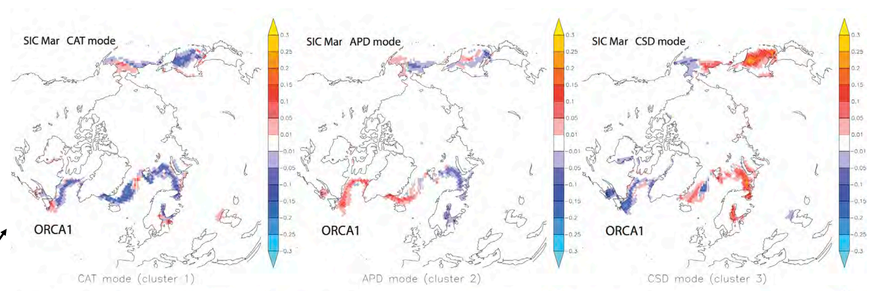


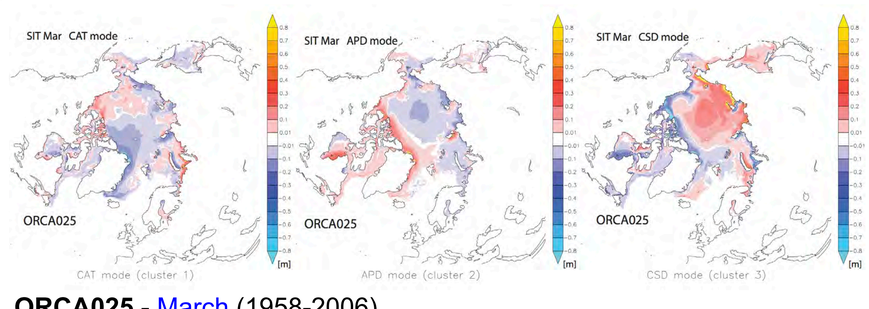
ORCA1 - March (1958-2006)

K-means cluster analysis (*K*=3) of ORCA1 model's SIT (time series of cluster occurrences and cluster centers) with the associated composites of model's and HadiSST2.2 SIC

We approximate the long-term change over the 1958-2006 periods with a 2nd order polynomial fit and then apply K-means cluster analysis of 2nd order residuals of the NH SIT → then the time series of SIT cluster occurrences is used to composite 2nd order residuals of sea ice concentration (SIC)

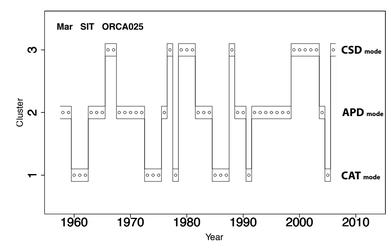


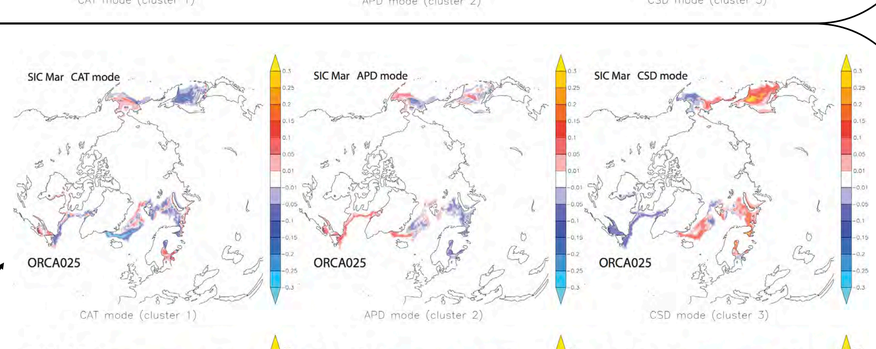


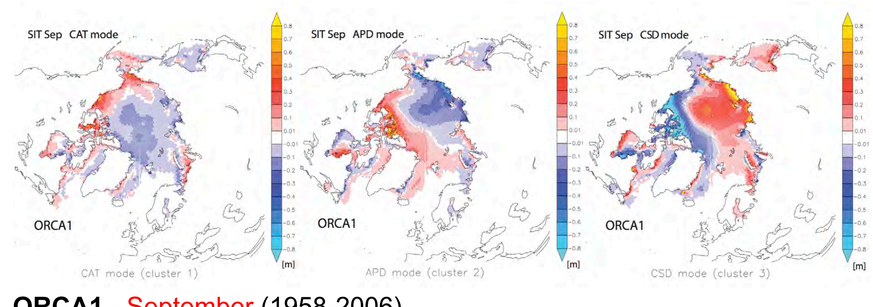


ORCA025 - March (1958-2006)

K-means cluster analysis (*K*=3) of ORCA025 model's SIT (time series of cluster occurrences and cluster centers) with the associated composites of model's and HadiSST2.2 SIC

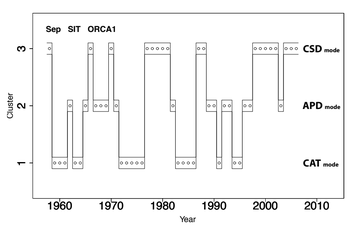


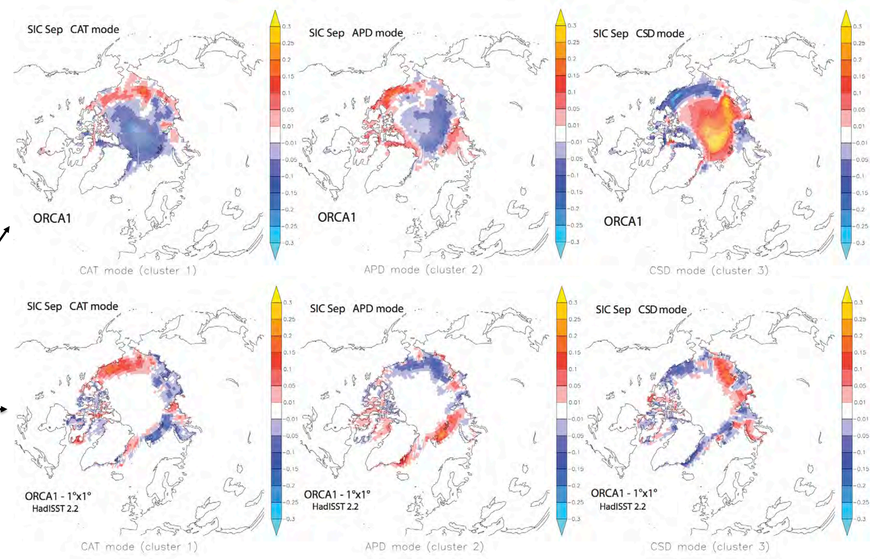


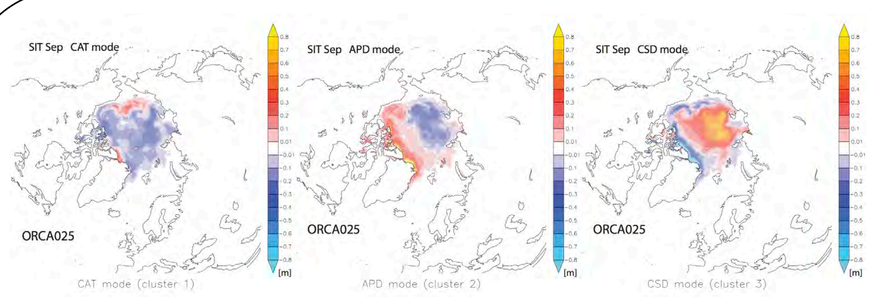


ORCA1 - September (1958-2006)

K-means cluster analysis (*K*=3) of ORCA1 model's SIT (time series of cluster occurrences and cluster centers) with the associated composites of model's and HadiSST2.2 SIC

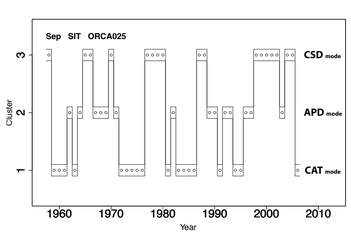


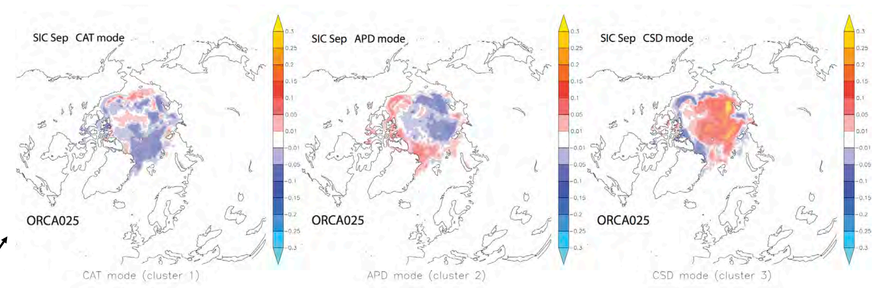




ORCA025 - September (1958-2006)

K-means cluster analysis (*K*=3) of ORCA025 model's SIT (time series of cluster occurrences and cluster centers) with the associated composites of model's and HadiSST2.2 SIC





● We have confirmed the existence of three NH SIT modes: Central Arctic Thinning (CAT) mode (cluster 1), Atlantic-Pacific Dipole (APD) mode (cluster 2), and Canadian-Siberian Dipole (SCD) mode (cluster 3) from Fučkar et al. 2016

● SIT monthly time series of mode occurrences in simulations with different horizontal resolutions show small differences, but overall their persistence reaches up to inter-annual timescales (not shown)

● The pattern of CAT mode exhibits the highest level of inter-seasonal and inter-resolution variability (i.e., APD and CSD modes are more consistent among different model's resolutions and different months)

● Model's and HadISSTv2.2 SIC composites shows appropriate match close to the marginal zones in all months, but simulations have too much variability in central Arctic

● ORCA1 (ORCA025) often has a stronger amplitude of pattern ano-malies in winter (summer) than ORCA025 (ORCA1)